SPECIFIED GAS EMITTERS REGULATION

QUANTIFICATION PROTOCOL FOR THE ANAEROBIC DECOMPOSITION OF AGRICULTURAL MATERIALS

SEPTEMBER 2007

Version 1

Alberta ENVIRONMENT

LBERTANS CLIMATE CHANGE

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1.0 Project and Methodology Scope and Description

This quantification protocol is written for those familiar with anaerobic digester projects. Some familiarity with, or general understanding of, the operation of these projects is expected.

The opportunity for generating carbon offsets with this protocol arises primarily from the indirect reductions of greenhouse gas (GHG) emissions from displacing fossil fuel based electricity, thermal energy or natural gas in gas transmission systems with the biogas from the anaerobic digestion of materials (primarily agricultural materials such as manure, silage, dead animal stocks, etc). There is a small opportunity to generate direct offsets from direct combustion or diversion of waste from landfills, if the full flexibility of the protocol is employed.

1.1 Protocol Scope and Description

The anaerobic digestion of organic material produces biogas which ranges from 40 to 60% methane depending on the feedstocks used. The agricultural material may represent part or all of the feedstock to the renewable energy facility. Typically anaerobic digestion of agricultural material involves the establishment of an integrated material management system for single or multiple agricultural facilities. Anaerobic digesters, generators, thermal energy recovery systems, biogas processing, fertilizer production, and/or water treatment systems may all be built on a site to handle any number of agricultural materials.

The most prevalent feedstocks are animal manures, silage and dead animal stocks. These materials are collected, transported to the facility, processed, and anaerobically digested, with the resulting materials being processed, combusted and disposed. **FIGURE 1.1** offers a process flow diagram for a typical project.

Protocol Approach
To demonstrate that a project is covered by the scope of the protocol, the project developer must demonstrate that the agricultural material would have been managed differently (collected, processed, and either land spread, sent to landfill or incinerated as per the current agricultural practices). As evidence, the project developer must demonstrate that this baseline condition, illustrated in **FIGURE 1.2**, was either the previous practise or most likely practise. Further, they must show that the agricultural material has been treated in an anaerobic digestion facility.

Facilities that cannot show that the agricultural material would have been either managed differently, or that the agricultural material was anaerobically digested, cannot apply this quantification protocol. Note – the Pork Protocol in this series of standards, could be applied in conjunction with this protocol for those who are integrating a Digester facility with pork operations. This would allow the calculation of direct emission reductions from changes in manure management.

FIGURE 1.1: Process Flow Diagram for Project Condition

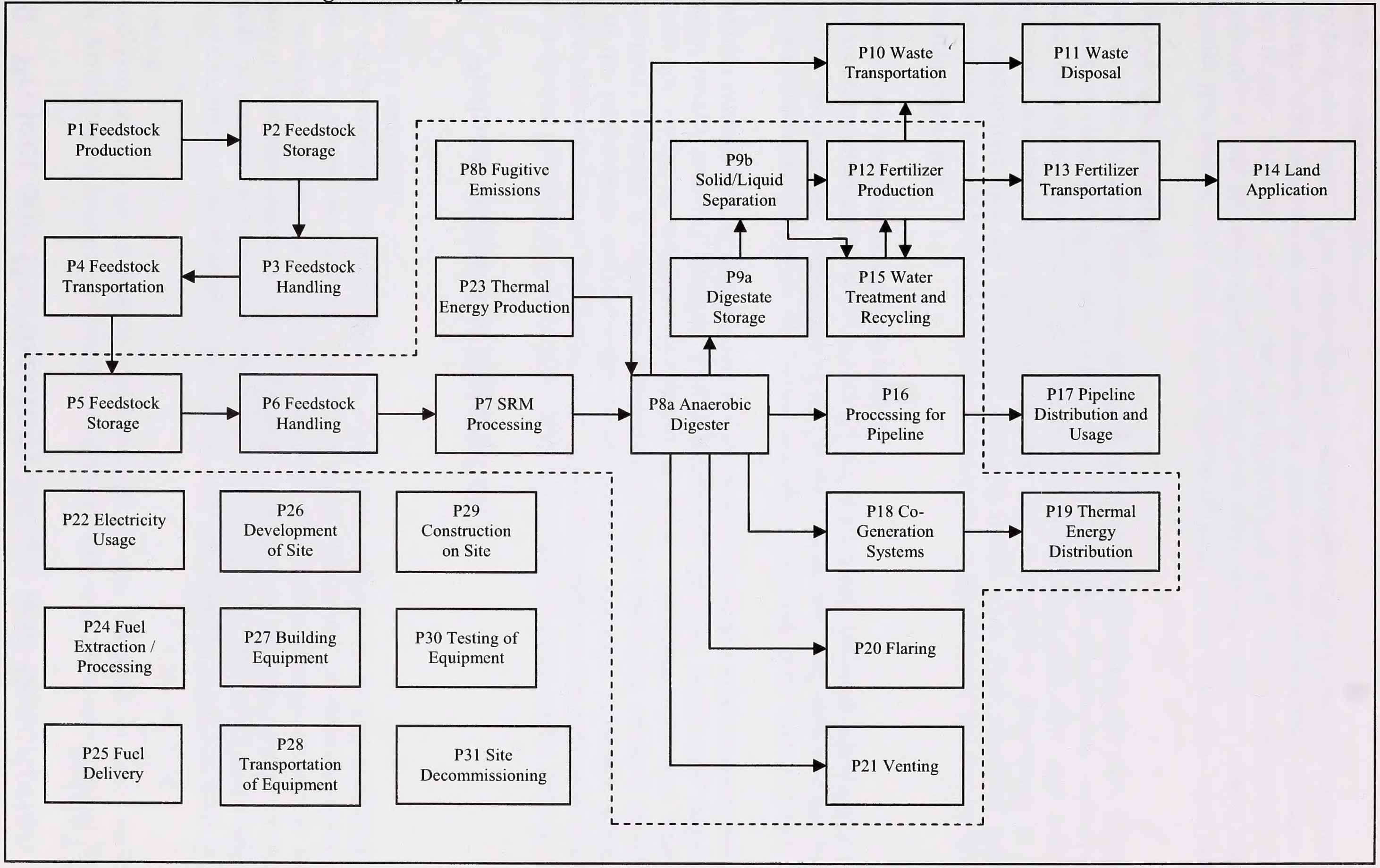
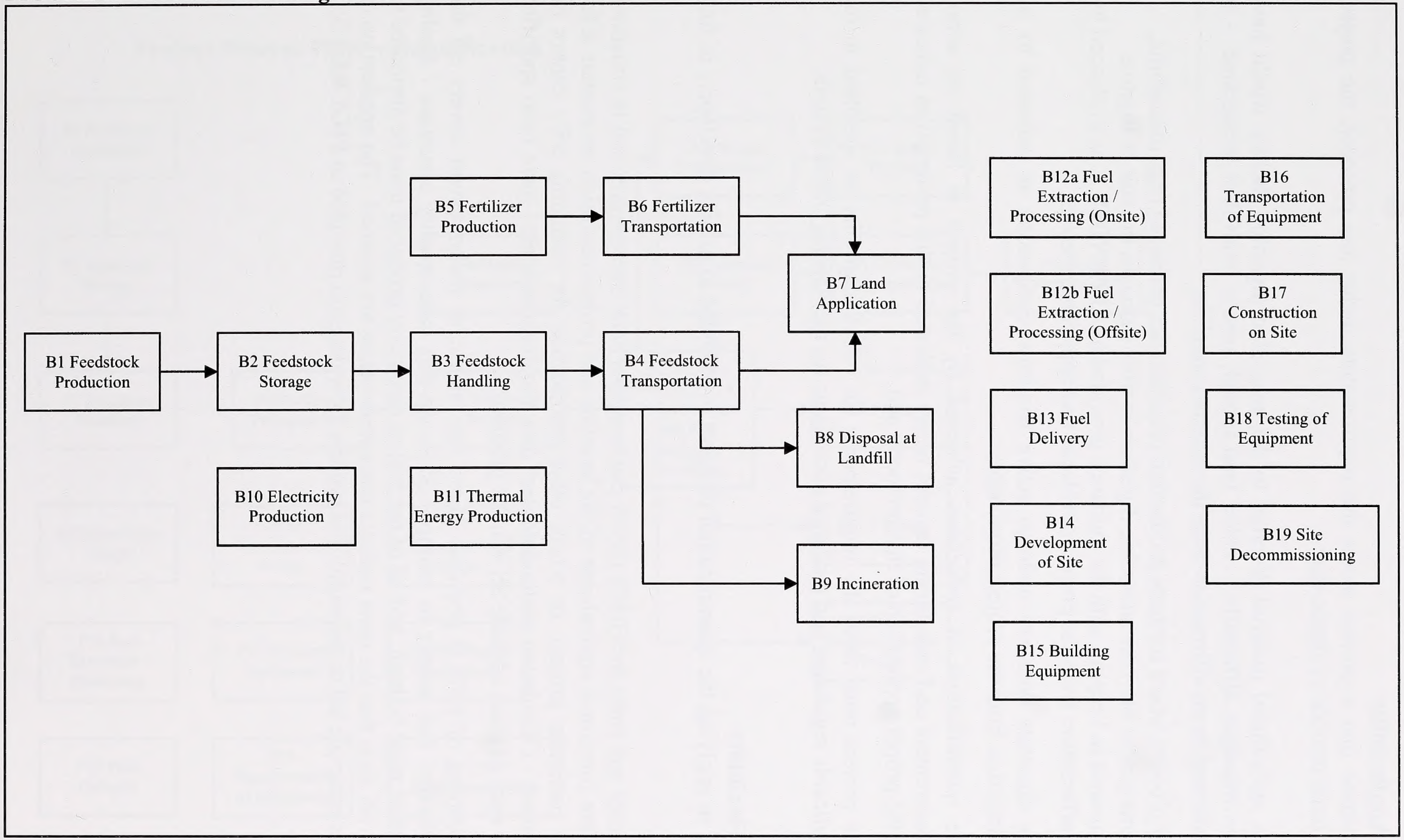


FIGURE 1.2: Process Flow Diagram for Baseline Condition



Protocol Applicability

To demonstrate that a project meets the requirements under this protocol, the project developer must provide evidence that:

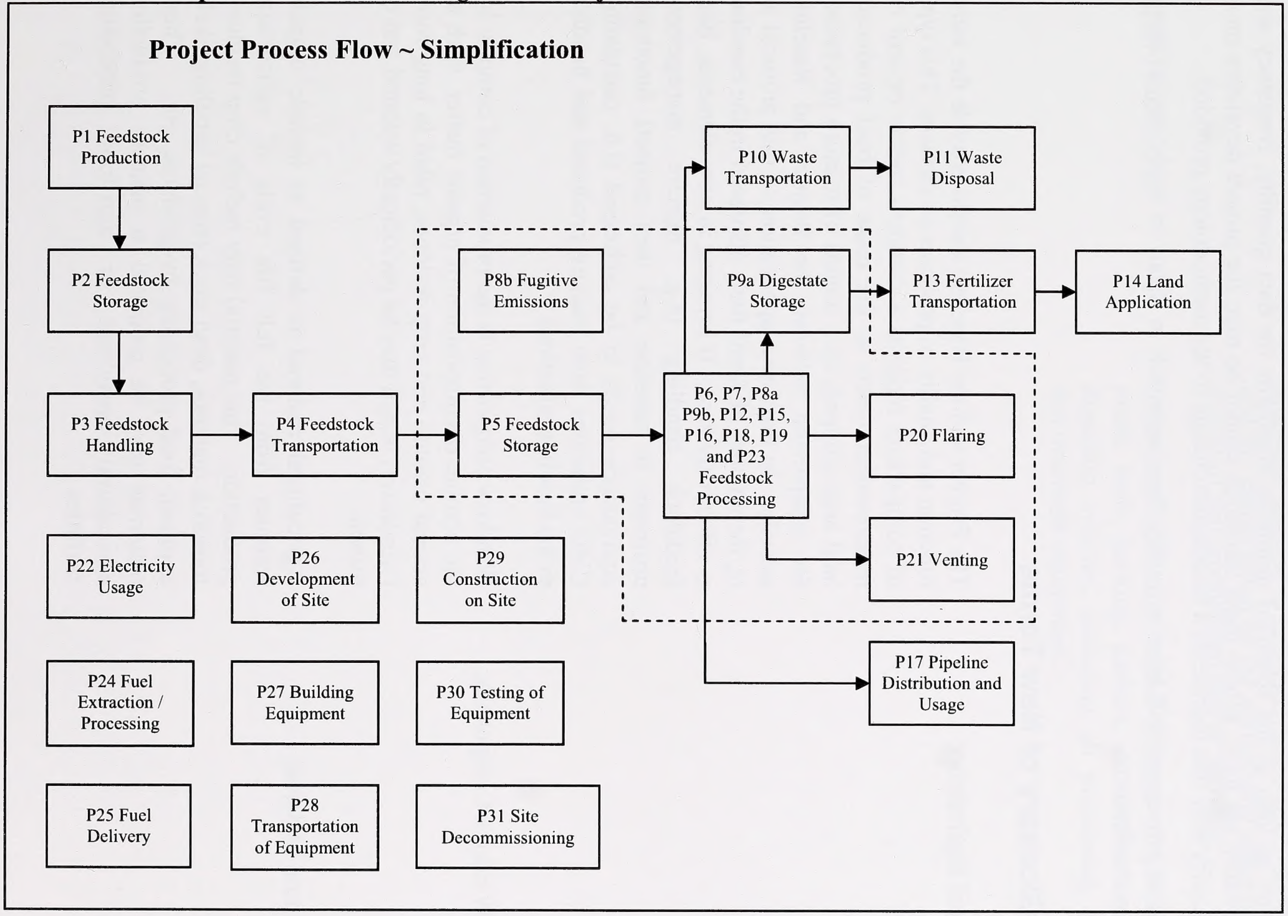
1. The agricultural material diverted to the anaerobic digestion facility would have been managed differently - either land spread, sent to landfill or incinerated - as confirmed by an affirmation from the biomass supplier;
2. For projects where methane production processes are enhanced (e.g. mesophilic, thermophilic, etc.) the anaerobic digestion facility manages the risk of fugitive emissions in keeping with the guidance provided in **APPENDIX A** as evidenced by an affirmation from the project developer and applicable records;
3. The digestate does not undergo active windrow composting as indicated by an affirmation from the project proponent;
4. The quantification of reductions achieved by the project is based on actual measurement and monitoring (except where indicated in this protocol) as indicated by the proper application of this protocol; and,
5. The project must meet the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System.

Protocol Flexibility

Flexibility in applying the quantification protocol is provided to project developers in four ways:

1. Source and sinks for GHGs (SS's) can be added back into the protocol in situations where functional equivalence of the baseline and project condition necessitate it for the particular project, or where other justification for excluding SS's cannot be assured. Calculation methodologies, data requirements, etc., have been specified for each of these addable SS's in the protocol;
2. Grouping of SS's is possible where one metric or measurement covers off the collective fuel supply to multiple SS's. In this case, quality assurance / quality control must be high, and all of the fuel or electricity produced must be attributed to the SS such that the most realistic emissions values are attained. The application of this principle led to the simplified process flow diagram provided in **FIGURE 1.3**;

FIGURE 1.3: Simplified Process Flow Diagram for Project Condition



3. Site specific emission factors may be substituted for the generic emission factors indicated in this protocol document. The methodology for generation of these emission factors must ensure accuracy; and be robust enough to provide uncertainty ranges in the factors;
4. Measurement and data management procedures may be modified by the project developer to account for the available equipment (e.g. Energy efficiency ratings, etc) as long as the specified minimum standards for data quantity, frequency and quality are met. Where these standards cannot be met, the project developer must justify why this represents a reasonable change to the methodology provided.

The project proponent will have to justify their approach in detail to apply any of these flexibility mechanisms.

1.2 Glossary of New Terms

Functional Equivalence	The Project and the Baseline should provide the same function and quality of products or services. This type of comparison requires a common metric or unit of measurement (such as the mass of beef produced, land area cropped, etc., tonnes of manure processed) for comparison between the Project and Baseline activity. In the direct application of this protocol as is, the amount of fossil fuels displaced in the baseline is effectively zero. If bringing in new elements, like, feedstock handling (e.g. manure management upstream in baseline and then project) functional equivalence needs to be addressed (i.e. calculating GHG emissions from manure produced and handled in the baseline situation).
Active Windrow Composting:	Windrow composting is the production of compost by the aerobic decomposition of organic matter, such as animal manure and crop residues, piled in long rows (windrows) which may be periodically watered and/or turned.
Agricultural Material:	Agricultural material is defined to include organic residues from the full life cycle of agricultural production. This material may include crop residues, livestock manures, dead stock (special handling likely applies), food processing by-products, etc. These materials may be produced at primary production agricultural operations or agri-food processing facilities.

Anaerobic Digestion: An active and naturally occurring biological process where organic matter is degraded by methanogenic bacteria to yield methane gas and mineralized organic nutrients.

Land Application: The beneficial use of agricultural material and/or digestate, applied to cropland based upon crop needs and the composition of the agricultural material, as a source of soil amendment and/or nutrition.

Fugitive Emissions: Intentional and unintentional releases of GHGs from joints, seals, packing, gaskets, etc. within anaerobic digestion systems, including all processing, piping and treatment equipment.

2.0 Quantification Development and Justification

The following sections outline the quantification development and justification.

2.1 Identification of Sources and Sinks (SS's) for the Project

SS's were identified for the project by reviewing the relevant process flow diagrams, consulting with stakeholders (i.e. project proponents) and reviewing the good practise guidance. This iterative process confirmed that the SS's in the process flow diagrams covered the full scope of eligible project activities under the protocol.

Based on the process flow diagrams provided in **FIGURE 1.1** and **FIGURE 1.3**, the project SS's were organized into life cycle categories in **FIGURE 2.1**. Descriptions of each of the SS's and their classification as controlled, related or affected are provided in **TABLE 2.1.**

FIGURE 2.1: Project Element Life Cycle Chart

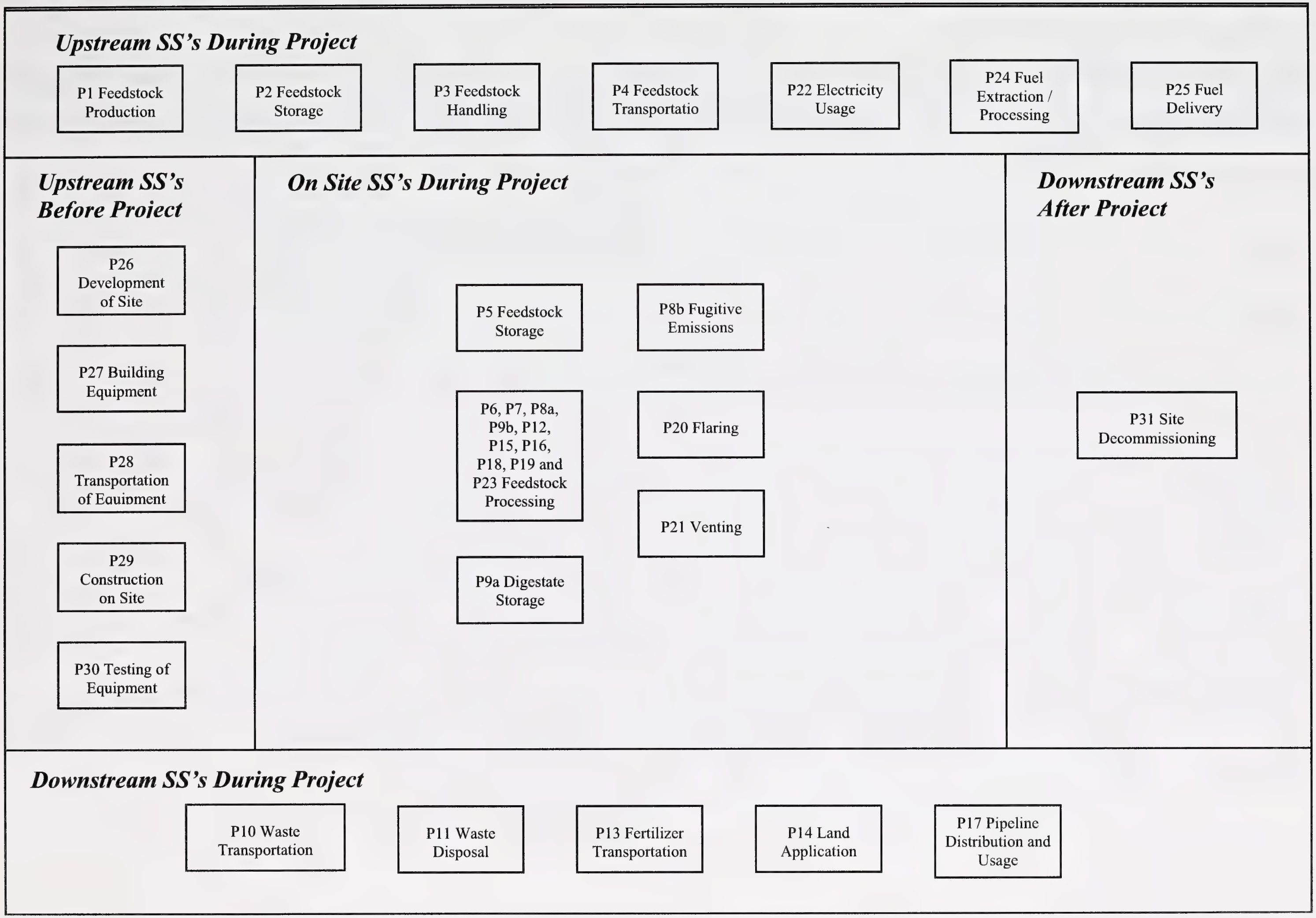


TABLE 2.1: Project SS's

1. SS	2. Description	3. Controlled, Related or Affected
Upstream SS's during Project Operation		
P1 Feedstock Production	Agricultural materials are produced in a number ways. Farm animals produce manure as part of their digestive cycle. The composition of this manure is impacted by the ration they are fed. The ration is a function of the animal's life-stage, production target, climate and ration market dynamics. Other agricultural materials include dead-stock and materials from the harvesting and/or processing of various crops or agricultural products. Greenhouse gas emissions may be associated with the collection and processing of the feedstock using various mechanical farm equipment primarily powered by diesel and natural gas. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Related
P2 Feedstock Storage	Feedstock may be stored at the farm site, in the animal pens, in windrows, piles or in enclosed containers. Greenhouse gas emissions may result from the anaerobic decomposition of these materials if storage conditions allow for an oxygen deficient atmosphere or from volatilization of nitrogen as nitrous oxide under aerobic conditions. The characteristics size, shape, composition and duration of storage are all pertinent to evaluate functional equivalence with the baseline condition.	Related
P3 Feedstock Handling	Feedstock may be handled and/or processed prior to transportation. This may involve the used of heavy equipment such as payloaders or excavators that operate using diesel or natural gas. Emissions of greenhouse gases are associated with the use of these energy sources. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Related
P4 Feedstock Transportation	Feedstock may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
P22 Electricity Usage	Electricity may be required for operating the facility. This power may be sourced either from internal generation, connected facilities or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid. Quantity and source of power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions.	Related
P24 Fuel Extraction / Processing	Each of the fuels used throughout the on-site component of the project will need to be sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site SS's are considered under this SS. Volumes and types of fuels are the important characteristics to be tracked.	Related

P25 Fuel Delivery	Each of the fuels used throughout the on-site component of the project will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gases. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other SS's and there are no other delivery emissions as the fuel is already going to the commercial fuelling station. Distance and means of fuel delivery as well as the volumes of fuel delivered are the important characteristics to be tracked.	Related
Onsite SS's during Project Operation		
P5 Feedstock Storage	Feedstock may then be stored on site in piles or in enclosed containers. Greenhouse gas emissions may result from the anaerobic decomposition of these materials if storage conditions allow for an oxygen deficient atmosphere or from volatilization of nitrogen as nitrous oxide under aerobic conditions. The characteristics of these storage piles, in terms of size, shape, composition and duration of storage may all need to be tracked.	Controlled
P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing	Feedstock may be handled and/or processed prior to being input to the anaerobic digester. This may involve the used of heavy equipment such as bull-dozers that operate using diesel or natural gas. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities for each of the energy inputs may all need to be tracked.	Controlled
	Regulations for handling dead stock may require specific processing. Specifically, this would address Special Risk Material (SRM) and may involve thermodynamic processes, or other mechanical processes. This may involve heating, cooling or processing using special equipment all of which would require either natural gas or diesel. Emissions of greenhouse gases are associated with the use of these energy sources. Quantities for each of the energy inputs may all need to be tracked.	Controlled
	Greenhouse gas emissions may occur that are associated with the operation and maintenance of the anaerobic digestion facility. This may include running any auxiliary or monitoring systems. Quantities and types for each of the energy inputs would be tracked.	Controlled
	Greenhouse gas emissions may occur that are associated with the separation of the solid and liquid phases of the digestate. The mechanical process for separating the solid and liquid components is sometimes electrical system, which would be tracked.	Controlled
	Digestate may be converted to fertilizer through mechanical and amendment processes. This requires several energy inputs such as natural gas. Emissions of greenhouse gases are associated with the use of these energy sources. Quantities and types for each of the energy inputs would be tracked.	Controlled
	Effluent water may be treated through mechanical and chemical processes prior to discharge or reuse. This requires several energy inputs such as natural gas and diesel. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities and types for each of the energy inputs would be tracked.	Controlled
	Effluent biogas will likely have a higher concentration of carbon dioxide and other impurities than may be acceptable to the pipeline operator. Mechanical equipment may be required to treat the biogas in order for the biogas to be suitable for inclusion in the pipeline system. This may require several energy inputs such as natural gas and diesel. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities and types for each of the energy inputs would be tracked.	Controlled

	Co-generation systems may be required to produce thermal energy for distribution. The operation of this equipment may require several energy inputs such as natural gas or diesel. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities and types for each of the energy inputs would be tracked.	Controlled
	Systems may be required to distribute the thermal energy to neighbouring sites. This may include pumps to circulate steam, hot oil or hot water. This equipment may require several energy inputs such as natural gas or diesel. Emissions of greenhouse gases are associated with the use of these energy sources. Quantities and types for each of the energy inputs would be tracked.	Controlled
	Thermal energy systems may be required to maintain the desired temperature for the anaerobic digester. This may include boilers or similar, which may require several energy inputs such as natural gas or diesel. Emissions of greenhouse gases are associated with the use of these energy sources. Quantities and types for each of the energy inputs would be tracked.	Controlled
P8b Fugitive Emissions	Greenhouse gas emissions may also result from fugitive emissions associated with the operation of the anaerobic digestion facility. These emissions would primarily be methane emissions associated with leaks through valves, connections and equipment seals as many of the facility components operate under pressure. Quantities of fugitive emissions would need to be measured or estimated.	Controlled
P9a Digestate Storage	Greenhouse gas emissions may also result if the digestate needs to be stored temporarily after being removed from digester and before further processing. Further anaerobic decomposition may occur resulting primarily in methane emissions. Quantities of digestate being stored, the emissions intensity and residency time would need to be measured or estimated.	Controlled
P20 Flaring	Flaring of the biogas may be required during upset conditions or during maintenance to the elements downstream of the anaerobic digester. Emissions of greenhouse gases would be contributed from the combustion of the biogas as well as from any natural gas used in flaring to ensure more complete combustion. Quantities of biogas being flared and the quantities of natural gas would need to be tracked.	Controlled
P21 Venting	Venting of the biogas may be required during upset conditions or during maintenance to the elements downstream of the anaerobic digester. Emissions of the methane under these circumstances would need to be considered. The duration of the venting condition, methane production rate and the volume of biogas in the digester at the time of venting would all need to be tracked.	Controlled
Downstream SS's during Project Operation		
P10 Waste Transportation	Waste materials may be transported to disposal sites by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related

P11 Waste Disposal	Waste may be disposed of at a disposal site by transferring the waste from the transportation container, spreading, burying, processing, otherwise handling the waste using a combination of loaders, conveyors and other mechanized devices. This equipment would be fuelled by diesel, gas or natural gas, resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities and types for each of the energy inputs would be tracked.	Related
P13 Fertilizer Transportation	Fertilizer produced at the site will need to be transported to customers or distribution points by truck and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
P14 Land Application	The fertilizer produced at the site will then be land applied. This will require the use of heavy equipment and mechanical systems. This equipment would be fuelled by diesel, gas or natural gas, resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Related
P17 Pipeline Distribution and Usage	Biogas may be input to the pipeline system and distributed to customers at another point on the distribution system. This gas will be further processed or consumed by the consumer. The most reasonable fate would be combustion in a controlled manner as this relies on the highest emissions factors for the biogas. This quantity of biogas input to the pipeline system would need to be tracked.	Related
Other		
P26 Development of Site	The site of the anaerobic digestion facility may need to be developed. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer etc. This may also include clearing, grading, building access roads, etc. There will also need to be some building of structures for the facility such as storage areas, storm water drainage, offices, vent stacks, firefighting water storage lagoons, etc., as well as structures to enclose, support and house the equipment. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.	Related
P27 Building Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, system control and safety systems. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related
P28 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site, will all need to be delivered to the site. Transportation may be completed by truck, barge and/or train. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
P29 Construction on Site	The process of construction at the site will require a variety of heavy equipment, smaller power tools, cranes and generators. The operation of this equipment will have associated greenhouse gas emission from the use of fossil fuels and electricity.	Related

P30 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using test anaerobic digestion fuels or fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
P31 Site Decommissioning	Once the facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

2.2 Identification of Baseline

The baseline condition is considered as projection based. Under this scenario, the emissions from the disposal of an equivalent quantity of agricultural material being either land applied, sent to landfill or incinerated would be calculated using existing models covering the activities under the baseline condition.

This dynamic approach accounts for the market forces, weather and energy demand and operational parameters without adding multiple streams of material management. There are suitable models that can provide reasonable certainty.

The baseline condition is defined including the relevant SS's and processes as shown in **FIGURE 1.2**. More detail on each of these SS's is provided in Section 2.3, below.

2.3 Identification of SS's for the Baseline

Based on the process flow diagrams provided in **FIGURE 1.2**, the project SS's were organized into life cycle categories in **FIGURE 2.2**. Descriptions of each of the SS's and their classification as either 'controlled', 'related' or 'affected' is provided in **TABLE 2.2.**

FIGURE 2.2: Baseline Element Life Cycle Chart

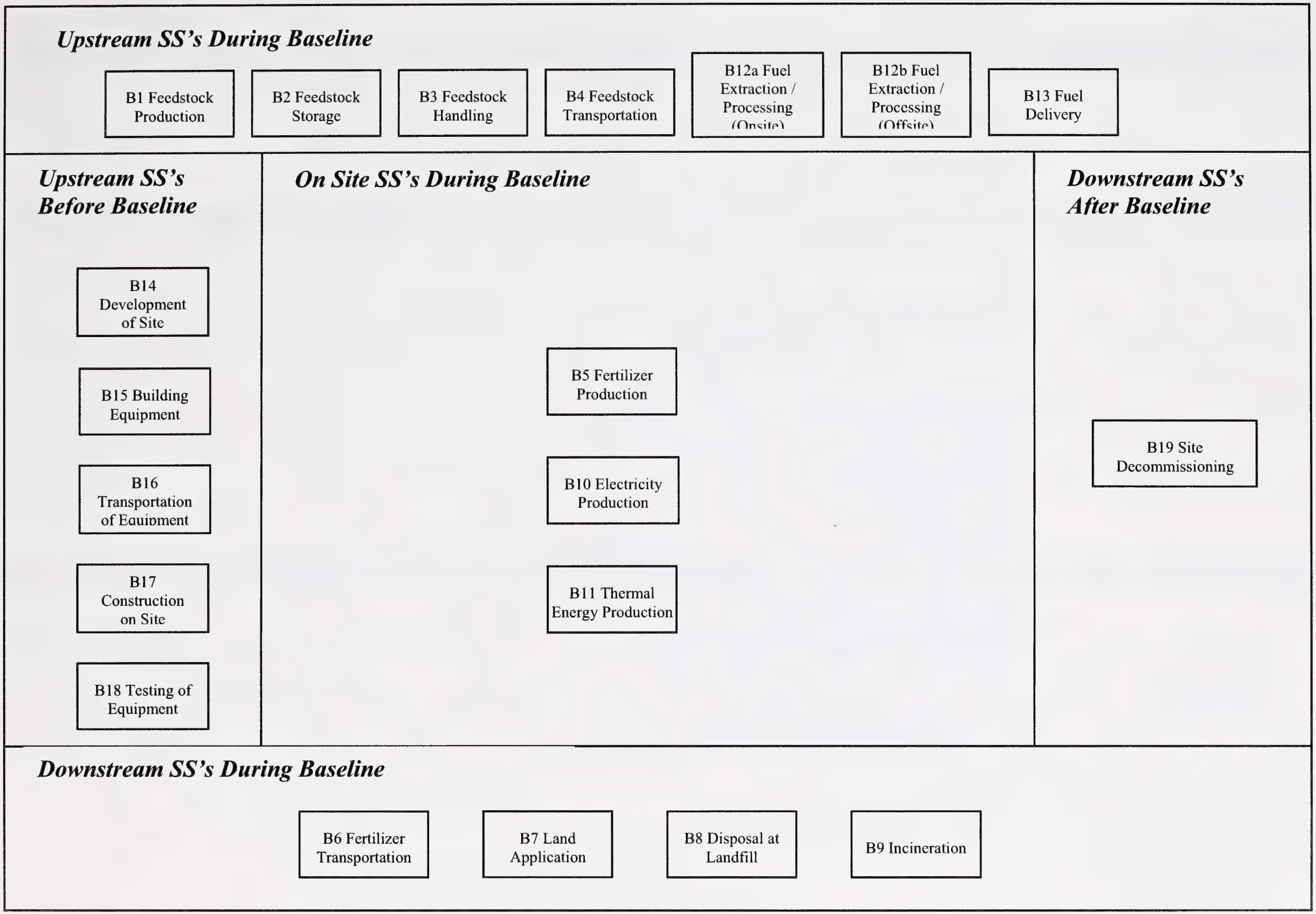


TABLE 2.2: Baseline SS's

1. SS	2. Description	3. Controlled, Related or Affected
Upstream SS's during Baseline Operation		
B1 Feedstock Production	Agricultural materials are produced in a number ways. Farm animals produce manure as part of their digestive cycle. The composition of this manure is impacted by the ration they are fed. The ration is a function of the animal's life-stage, production target, climate and ration market dynamics. Other agricultural materials include dead-stock and materials from the harvesting and/or processing of various crops or agricultural products. Greenhouse gas emissions may be associated with the collection and processing of the feedstock using various mechanical farm equipment primarily powered by diesel, natural gas and electricity. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
B2 Feedstock Storage	Feedstock may then be stored at the farm site, in the animal pens, in windrow, piles or in enclosed containers. Greenhouse gas emissions may result from the anaerobic decomposition of these materials if storage conditions allow for an oxygen deficient atmosphere. The characteristics size, shape, composition and duration of storage are all pertinent to evaluate functional equivalence with the project condition.	Related
B3 Feedstock Handling	Feedstock may be handled and/or processed prior to transportation. This may involved the used of heavy equipment such as bull-dozers that operate using diesel, natural gas or electricity. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
B4 Feedstock Transportation	Feedstock may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the project condition.	Related
B12a Fuel Extraction / Processing (Onsite)	Each of the fuels used throughout the on-site component of the project will need to sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site SS's are considered under this SS. Volumes and types of fuels are the important characteristics to be tracked.	Related

B12b Fuel Extraction / Processing (Offsite)	The biogas being input to the pipeline during the project condition offsets a volume of natural gas from the pipeline system. This volume of natural gas from the pipeline will need to sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the natural gas. The total volume of biogas input to the pipeline is considered under this SS and may need to be tracked.	Related
B13 Fuel Delivery	Each of the fuels used throughout the on-site component of the project will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gases. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other SS's and there is no other delivery.	Related
Onsite SS's during Project Operation		
B5 Fertilizer Production	Fertilizer may be produced through a number of chemical, mechanical and amendment processes. This requires several energy inputs such as natural gas, diesel and electricity. Emissions of greenhouse gases are associated with the use of these fossil fuels. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
B10 Electricity Production	Electricity will be produced off-site to cover the electricity demand not being produced by the anaerobic digestion facility. This electricity will be produced at an emissions intensity as deemed appropriate by the Program Authority. Measurement of the gross quantity of electricity produced by the facility will need to be tracked to quantify this SS.	Related
B11 Thermal Energy Production	The production of thermal energy may be required to meet the demands of facilities being provided with thermal energy from the project site. This thermal energy may have been derived from waste heat recovery systems resulting in an energy burden on the systems from which the heat is being recovered or directly from combustion of fossil fuels. Energy requirements, fuel volumes and fuel types will need to be tracked.	Related
Downstream SS's during Baseline Operation		
B6 Fertilizer Transportation	Fertilizer produced at the site will need to be transported to customers or distribution points by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this SS, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the project condition.	Related
B7 Land Application	Fertilizer and/or feedstock will then be land applied. This will require the use of heavy equipment and mechanical systems. This equipment would be fuelled by diesel, gas, natural gas or electricity, resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related

B8 Disposal in Landfill	Some feedstock may be disposed of at a disposal site by transferring the material from the transportation container, spreading, burying, processing, otherwise handling the material using a combination of loaders, conveyors and other mechanized devices. This equipment would be fuelled by diesel, gas, natural gas or electricity, resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities and types for each of the energy inputs would be tracked. Residues may decompose in the disposal facility (typically a landfill site) resulting in the production of methane. A methane collection and destruction system may be in place at the disposal site. If such a system is active in the area of the landfill where this material is being disposed, then this methane collection must be accounted for in a reasonable manner. Disposal site characteristics and mass disposed of at each site may need to be tracked as well as the characteristics of the methane collection and destruction system.	Related
B9 Incineration	Some feedstock may be incinerated at a disposal site. This will include combusting the materials with a fuel such as natural gas or diesel. Other fuels may also be used in some rare cases. Quantities for each of the energy inputs would be contemplated and tracked to evaluate functional equivalence with the project condition.	Related
Others		
B14 Development of Site	The site may need to be developed under the baseline condition. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer etc. This may also include clearing, grading, building access roads, etc. There will also need to be some building of structures for the facility such as storage areas and offices, etc., as well as structures to enclose, support and house any equipment. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.	Related
B15 Building Equipment	Equipment may need to be built either on-site or off-site. This can include the baseline components for the storage, handling and processing of the agricultural material. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related
B16 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site, will all need to be delivered to the site. Transportation may be completed by truck, barge and/or train. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
B17 Construction on Site	The process of construction at the site will require a variety of heavy equipment, smaller power tools, cranes and generators. The operation of this equipment will have associated greenhouse gas emission from the use of fossil fuels and electricity.	Related

B18 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using test agricultural materials or fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
B19 Site Decommissioning	Once the facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

2.4 Selection of Relevant Project and Baseline SS's

Each of the SS's from the project and baseline condition were compared and evaluated as to their relevancy using the guidance provided in Annex VI of the "Guide to Quantification Methodologies and Protocols: Draft", dated March 2006 (Environment Canada). The justification for the exclusion or conditions upon which SS's may be excluded is provided in **TABLE 2.3** below. All other SS's listed previously are included.

TABLE 2.3: Comparison of SS's

1. Baseline Options	2. Baseline (C, R, A)	2. Project (C, R, A)	4. Include or Exclude from Quantification	5. Justification for Exclusion
Upstream SS's				
P1 Feedstock Production	N/A	Related	Exclude	Changes in livestock rations may yield differing energy values for manure. However, rations are typically tied to yield from the animal, availability, cost, etc. Further, the impacts of changes in feed regimes on enteric emissions from livestock are not sufficiently understood as to provide accuracy in measurement or estimation, in an economically efficient monitoring regime. Production of other feedstocks would likely be functionally equivalent as they are produced under normal operation. For these reasons, it is reasonable to exclude these SS's.
B1 Feedstock Production	Related	N/A	Exclude	
P2 Feedstock Storage	N/A	Related	Exclude	Under the majority of project and baseline configurations, the duration that the material is stored will be less under the project condition as compared to the baseline. This is reasonable given that collection will be planned in order to capture the material when it has a higher energy value. Further collection frequencies will be shorter to ensure more continual supply of feedstock to the anaerobic digestion system. As the duration of storage is shorter, it is reasonable to assume that these SS's may be excluded as the baseline emissions will exceed the project emissions.
B2 Feedstock Storage	Related	N/A	Exclude	
P3 Feedstock Handling	N/A	Related	Exclude	Excluded as under the majority of configurations, the project condition is equivalent to the baseline scenario.
B3 Feedstock Handling	Related	N/A	Exclude	
P4 Feedstock Transportation	N/A	Related	Exclude	Excluded as under the majority of configurations, the project condition is equivalent to the baseline scenario.
B4 Feedstock Transportation	Related	N/A	Exclude	
P22 Electricity Usage	N/A	Related	Exclude	Excluded as these SS's are not relevant to the project as the emissions from these practises are covered under proposed greenhouse gas regulations.
P24 Fuel Extraction / Processing	N/A	Related	Exclude	Excluded as these SS's are not relevant to the project as the emissions from these practises are covered under proposed greenhouse gas regulations.
B12a Fuel Extraction / Processing (Onsite)	Related	N/A	Exclude	
B12b Fuel Extraction / Processing (Offsite)	Related	N/A	Include	N/A
P25 Fuel Delivery	N/A	Related	Exclude	Excluded as these SS's are not relevant to the project as the emissions from these practises are covered under proposed greenhouse gas regulations.
B13 Fuel Delivery	Related	N/A	Exclude	

Onsite SS's				
P5 Feedstock Storage	N/A	Controlled	Exclude	As per the discussion for B2 and P2 Feedstock Storage, the storage of these materials is minimized in order to capture the highest energy value. Further, limited inventory of agricultural materials are maintained on site as should there be an up-set condition, having these materials on-site could bring forward storage issues such as odour. For these reasons, it is reasonable to exclude this SS.
P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing	N/A	Controlled	Include	N/A
P8b Fugitive Emissions	N/A	Controlled	Exclude	Excluded as projects applying this protocol must meet the requirements of with Sections 10.2 through 10.4 of the Canadian Standards Association (CSA) Code for Digester Gas and Landfill Gas Installations CAN/CGA-B105-M93 which specifies the relevant leakage and pressure testing requirements providing reasonable assurance that fugitive emissions are immaterial.
P9a Digestate Storage	N/A	Controlled	Exclude	The digestate removed from the anaerobic digestion vessel(s) may continue to produce methane emissions if not aerated or nitrous oxide emissions if aerated. Separation of the solid and liquid components can serve to stabilize the digestate in order to minimize the continuation of the anaerobic digestion processes would continue outside of the digestion chamber. Under the condition that the digestate does not undergo active composting, the emissions from secondary storage are immaterial.
P20 Flaring	N/A	Controlled	Include	N/A
P21 Venting	N/A	Controlled	Include	N/A
B5 Fertilizer Production	N/A	Related	Exclude	Excluded as these SS's are not relevant to the project as the emissions from these practises are covered under proposed greenhouse gas regulations.
B10 Electricity Production	Related	N/A	Include	N/A
B11 Thermal Energy Production	Related	N/A	Include	N/A
Downstream SS's				
P10 Waste Transportation	N/A	Related	Exclude	Excluded as quantity of waste and related emissions from its transport are negligible.
P11 Waste Disposal	N/A	Related	Exclude	Excluded as the waste is essentially inert and its disposal would not contribute to methane production, and would have no impact on methane collection and destruction systems.

P13 Fertilizer Transportation	N/A	Related	Exclude	Excluded as under the majority of configurations, the project condition is equivalent to the baseline scenario.
B6 Fertilizer Transportation	Related	N/A	Exclude	
P14 Land Application	N/A	Related	Exclude	The nitrogen stabilization in the project condition (P12 Land Application) is such that the amount of nitrous oxide released will be less and the amount of carbon that is biologically sequestered in the soil will be greater than in the baseline condition (B7 Land Application). As this involves complex data capture, management and calculation, involving considerable uncertainty, it is reasonable to exclude the emission reductions from this SS's.
B7 Land Application	Related	N/A	Exclude	
P17 Pipeline Distribution and Usage	N/A	Related	Include	N/A
B8 Disposal in Landfill	Related	N/A	Include	N/A
B9 Incineration	Related	N/A	Include	N/A
Other				
P26 Development of Site	N/A	Related	Exclude	Emissions from site development are not material given the long project life, and the minimal site development typically required.
B12 Development of Site	Related	N/A	Exclude	Emissions from site development are not material for the baseline condition given the minimal site development typically required.
P27 Building Equipment	N/A	Related	Exclude	Emissions from building equipment are not material given the long project life, and the minimal building equipment typically required.
B13 Building Equipment	Related	N/A	Exclude	Emissions from building equipment are not material for the baseline condition given the minimal building equipment typically required.
P28 Transportation of Equipment	N/A	Related	Exclude	Emissions from transportation of equipment are not material given the long project life, and the minimal transportation of equipment typically required.
B14 Transportation of Equipment	Related	N/A	Exclude	Emissions from transportation of equipment are not material for the baseline condition given the minimal transportation of equipment typically required.
P29 Construction on Site	N/A	Related	Exclude	Emissions from construction on site are not material given the long project life, and the minimal construction on site typically required.
B15 Construction on Site	Related	N/A	Exclude	Emissions from construction on site are not material for the baseline condition given the minimal construction on site typically required.
P30 Testing of Equipment	N/A	Related	Exclude	Emissions from testing of equipment are not material given the long project life, and the minimal testing of equipment typically required.
B16 Testing of Equipment	Related	N/A	Exclude	Emissions from testing of equipment are not material for the baseline condition given the minimal testing of equipment typically required.
P31 Site Decommissioning	N/A	Related	Exclude	Emissions from decommissioning are not material given the long project life, and the minimal decommissioning typically required.
B17 Site Decommissioning	Related	N/A	Exclude	Emissions from decommissioning are not material for the baseline condition given the minimal decommissioning typically required.

2.5 Quantification of Reductions, Removals and Reversals of Relevant SS's

2.5.1 Quantification Approaches

Quantification of the reductions, removals and reversals of relevant SS's for each of the greenhouse gases will be completed using the methodologies outlined in **TABLE 2.4**, below. Quantification methods for the SS's under the flexibility mechanisms are provided in **APPENDIX B**. These calculation methodologies serve to complete the following three equations for calculating the emission reductions from the comparison of the baseline and project conditions.

$$\text{Emission Reduction} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}$$

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Feedstock Disposal}} + \text{Emissions}_{\text{Incineration}} + \text{Emissions}_{\text{Electricity}} + \text{Emissions}_{\text{Thermal Heat}} + \text{Emissions}_{\text{Fuel Extraction / Processing}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Multiple Sources}} + \text{Emissions}_{\text{Pipeline Distribution and Usage}} + \text{Emissions}_{\text{Flaring}} + \text{Emissions}_{\text{Venting}}$$

Where:

$\text{Emissions}_{\text{Baseline}}$ = sum of the emissions under the baseline condition.

$\text{Emissions}_{\text{Feedstock Disposal}}$ = emissions under SS B8 Disposal in Landfill.

$\text{Emissions}_{\text{Incineration}}$ = emissions under SS B9 Incineration.

$\text{Emissions}_{\text{Electricity}}$ = emissions under SS B10 Electricity Production.

$\text{Emissions}_{\text{Thermal Heat}}$ = emissions under SS B11 Thermal Energy Produced.

$\text{Emissions}_{\text{Fuel Extraction / Processing}}$ = emissions under SS B12b Fuel Extraction/ Processing (Offsite).

$\text{Emissions}_{\text{Project}}$ = sum of the emissions under the project condition.

$\text{Emissions}_{\text{Multiple Sources}}$ = emissions under SS P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing

$\text{Emissions}_{\text{Pipeline Distribution and Usage}}$ = emissions under SS P17 Pipeline Distribution and Usage

$\text{Emissions}_{\text{Flaring}}$ = emissions under SS P20 Flaring

$\text{Emissions}_{\text{Venting}}$ = emissions under SS P21 Venting

TABLE 2.4: Quantification Procedures

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
Project SS's						
P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing	Emissions $_{Multiple\ Sources}$ = (Vol. Biogas $_{Combusted}$ * % CH_4 * EF Biogas CH_4) ; (Vol. Biogas Combusted * % CH_4 * EF Biogas N_2O) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ N2O}$)					
	Emissions $_{Multiple\ Sources}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Volume of Biogas Combusted / Vol. Biogas $_{Combusted}$	m^3	Measured	Direct metering of volume of biogas being combusted.	Continuous metering.	Direct metering is standard practise. Frequency of metering is highest level possible.
	Methane Composition in Biogas / % CH_4	-	Measured	Direct measurement.	Monthly or upon change in feedstock.	Biogas composition should remain relatively stable during steady-state operation. Material changes in feedstock would warrant additional measurement.
	CH_4 Emissions Factor for Biogas / EF Biogas $_{CH4}$	kg CH_4 per m^3	Estimated	From Environment Canada reference documents. In the absence of biogas data, rely on Electric Utilities emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the biogas.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

	N_20 Emissions Factor for Biogas / EF Biogas $_{N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents. In the absence of biogas data, rely on Electric Utilities emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the biogas.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	Volume of Each Type of Fuel / Vol Fuel $_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P17 Pipeline Distribution and Usage	Emissions $_{Pipeline\ Distribution\ and\ Usage}$ = (Vol Fuel $_{Pipeline}$ * % CH_4 * EF Biogas $_{CH4}$) ; (Vol Fuel $_{Pipeline}$ * % CH_4 * EF Biogas $_{N2O}$)					
	Emissions $_{Pipeline\ Distribution\ and\ Usage}$	kg of CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated.
	Volume of Biogas Piped from the Site / Vol Fuel $_{Pipeline}$	m^3	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.

	Methane Composition in Biogas / % CH_4	-	Measured	Direct measurement.	Monthly or upon change in feedstock.	Biogas composition should remain relatively stable during steady-state operation. Material changes in feedstock would warrant additional measurement.
	CH_4 Emissions Factor for Biogas / EF Biogas $_{CH4}$	kg CH_4 per m^3	Estimated	From Environment Canada reference documents. In the absence of biogas data, rely on Electric Utilities emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the biogas.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Biogas / EF Biogas $_{N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents. In the absence of biogas data, rely on Electric Utilities emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the biogas.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P20 Flaring	Emissions $_{Flaring}$ = (Vol. Biogas Flared * % CH_4 * EF Biogas $_{CH4}$) ; (Vol. Biogas Flared * % CH_4 * EF Biogas $_{N2O}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; $\sum$ (Vol. Fuel $_i$ * EF Fuel $_{i\ N2O}$)					
	Emissions $_{Flaring}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Volume of Biogas Flared / Vol. Biogas Flared	m^3	Measured	Direct metering of volume of biogas being flared.	Continuous metering.	Direct metering is standard practise. Frequency of metering is highest level possible.

	Methane Composition in Biogas / % CH_4	-	Measured	Direct measurement.	Monthly or upon change in feedstock.	Biogas composition should remain relatively stable during steady-state operation. Material changes in feedstock would warrant additional measurement.
	CH_4 Emissions Factor for Biogas / EF Biogas $_{CH4}$	kg CH_4 per m^3	Estimated	From Environment Canada reference documents. In the absence of biogas data, rely on Electric Utilities emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the biogas.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Biogas / EF Biogas $_{N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents. In the absence of biogas data, rely on Electric Utilities emissions factors for Natural Gas as this most accurately reflects the condition for the methane fraction of the biogas.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	Volume of Each Type of Fuel used to Supplement Flare / Vol Fuel $_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P21Venting	Emissions $_{Venting}$ = (Max. Storage Vol. $_{Vessel}$ + Flow Biogas $_{Vessel}$ * Time $_{Venting}$) * % CH_4					
	Emissions $_{Venting}$	kg of CH_4	N/A	N/A	N/A	Quantity being calculated.
	Maximum volume of biogas stored in Vessel at Steady State / Max. Storage Vol. $_{Vessel}$	m^3	Estimated	From facility engineering specifications.	Annual	Reference value will remain consistent unless system is re-engineered (i.e. change to maximum storage volume from change in cap).
	Flow Rate of Biogas at Steady State / Flow Biogas $_{Vessel}$	m^3 / hr	Measured	Average flow rate of biogas from the digester at steady state for the preceding period.	Weekly	Biogas flow rates are steady state for the previous week should provide reasonable approximation of flow rate at time of venting.
	Time that vessel is venting / t	days	Measured / Estimated	Number of partial or complete days of venting either measured or estimated from site records of energy production, witness accounts, etc.	Continuous	Number of days in a year is an absolute value.
	Methane Composition in Biogas / % CH_4	-	Measured	Direct measurement.	Annual or upon change in feedstock.	Biogas composition should remain relatively stable during steady-state operation. Material changes in feedstock would warrant additional measurement.
Baseline SS's						
B8 Disposal at Landfill	Emissions $_{Feedstock\ Disposal}$ = (Mass $_{Feedstock\ Landfill}$ * MCF * DOC * DOC_F * F * 16/12 - R) * (1 - OX)					
	Emissions $_{Feedstock\ Disposal}$	kg of CH_4	N/A	N/A	N/A	Quantity being calculated.

	Mass of Feedstock to Landfill / Mass Feedstock Landfill	kg	Measured	Direct measurement of mass of feedstock diverted to disposal site or landfill facility.	Measurement of each load of waste prior to its being disposed of onsite or as it is received at the landfill facility.	Measuring the mass of each load prior to its being disposed of onsite or as it is received at the landfill facility represents the industry practise.
	Methane Correction Factor / MCF	-	Estimated	Calculated based on IPCC and Environment Canada guidelines, provided in Appendix D and E.	Annual	Values calculated based on values published by IPCC. Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Degradable Organic Carbon / DOC	-	Estimated	Calculated based on IPCC and Environment Canada guidelines, provided in Appendix D and E.	Annual	Values calculated based on values published by IPCC. Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Fraction of Degradable Organic Carbon Dissimilated / DOC_F	-	Estimated	Calculated based on IPCC and Environment Canada guidelines, provided in Appendix D and E.	Annual	Values calculated based on values published by IPCC. Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Fraction of CH_4 in Off gas from Disposal Site / F	-	Estimated	From IPCC guidelines.	Annual	Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Recovered CH_4 at Disposal Site / R	kg of CH4	Measured	From IPCC guidelines.	Annual	Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Oxidation Factor / OX	-	Estimated	From IPCC guidelines.	Annual	Reference values adjusted periodically as part of internal IPCC review of its methodologies.

B9 Incineration	$Emissions_{Incineration} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\,CO2})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\,CH4})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\,N2O})$					
	$Emissions_{Incineration}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Volume of Each Type of Fuel used for incineration / Vol Fuel $_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\,CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\,CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\,N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
B10 Electricity Production	$Emissions_{Electricity} = Electricity * EF_{Elec}$					
	$Emissions_{Electricity}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Electricity Sent to Grid / Electricity	kWh	Measured	Direct metering.	Continuous metering	Continuous direct metering represents the industry practise and the highest level of detail.
	Emissions Factor for Electricity / EF_{Elec}	kg of CO2e per kWh	Estimated	From Alberta Environment reference documents.	Annual	Reference values adjusted as appropriate by Alberta Environment.
B11 Thermal Energy Produced	$Emissions_{Thermal\ Heat} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\,CO2})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\,CH4})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\,N2O})$					
	$Emissions_{Thermal\ Heat}$	kg of CO_2 ; CH_4 ; N_2O	N/A	N/A	N/A	Quantity being calculated.

	Volume of Each Type of Fuel / Vol $Fuel_i$	L / m^3 / other	Measured	Calculated relative to metered quantity of thermal energy delivered to the customer converted to an equivalent volume of fuel.	Continuous metering	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
B12b Fuel Extraction / Processing (Offsite)	$Emissions_{Fuel\ Extraction\ /\ Processing} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$					
	$Emissions_{Fuel\ Extraction\ /\ Processing}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.
	Volume of Biogas Input to Pipeline / Vol Fuel	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Natural Gas / EF $Fuel_{CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

	CH_4 Emissions Factor for Natural Gas / EF Fuel $_{CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Natural Gas / EF Fuel $_{N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

2.5.2. Contingent Data Approaches

Contingent means for calculating or estimating the required data for the equations outlined in section 2.5.1 are summarized in **TABLE 2.5**, below. Contingencies for the equations under the flexibility mechanisms are provided in **Appendix C**.

2.6 Management of Data Quality

In general, data quality management must include sufficient data capture such that the mass and energy balances may be easily performed with the need for minimal assumptions and use of contingency procedures. The data should be of sufficient quality to fulfill the quantification requirements and be substantiated by company records for the purpose of verification.

The project proponent shall establish and apply quality management procedures to manage data and information. Written procedures should be established for each measurement task outlining responsibility, timing and record location requirements. The greater the rigour of the management system for the data, the more easily an audit will be to conduct for the project.

2.6.1 Record Keeping

Record keeping practises should include:

a. Electronic recording of values of logged primary parameters for each measurement interval;
b. Printing of monthly back-up hard copies of all logged data;
c. Written logs of operations and maintenance of the project system including notation of all shut-downs, start-ups and process adjustments;
d. Retention of copies of logs and all logged data for a period of 7 years; and
e. Keeping all records available for review by a verification body.

2.6.1 Quality Assurance/Quality Control (QA/QC)

QA/QC can also be applied to add confidence that all measurements and calculations have been made correctly. These include, but are not limited to:

a Protecting monitoring equipment (sealed meters and data loggers);
b Protecting records of monitored data (hard copy and electronic storage);
c Checking data integrity on a regular and periodic basis (manual assessment, comparing redundant metered data, and detection of outstanding data/records);
d Comparing current estimates with previous estimates as a ‘reality check’;
e Provide sufficient training to operators to perform maintenance and calibration of monitoring devices;

- f Establish minimum experience and requirements for operators in charge of project and monitoring; and
- g Performing recalculations to make sure no mathematical errors have been made.

TABLE 2.5: Contingent Data Collection Procedures

1.0 Project/Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Contingency Method	6. Frequency	7. Justify measurement or estimation and frequency
Project SS's						
P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing	Volume of Biogas Combusted / Vol. Biogas $_{Combusted}$	L / m^3 / other	Estimated	Reconciliation of heat and power produced against volume of biogas required to produce that power.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Methane Composition in Biogas / % CH_4	-	Estimated	Use previous year data, data that most accurately reflects current feedstock, or current year data retrospectively.	Annual	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Volume of Each Type of Fuel / Vol Fuel $_i$	L / m^3 / other	Estimated	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Electricity Usage / Electricity	kWh	Estimated	Reconciliation of power requirements for facility as per equipment output ratings.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P17 Pipeline Distribution and Usage	Volume of Biogas Piped from the Site / Vol Fuel $_{Pipeline}$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	Methane Composition in Biogas / % CH_4	-	Measured	Direct measurement.	Annual or upon change in feedstock.	Biogas composition should remain relatively stable during steady-state operation. Material changes in feedstock would warrant additional measurement.

P20 Flaring	Volume of Biogas Flared / Vol. Biogas Flared	L / m^3 / other	Estimated	Use volumetric calculation as per venting calculation: (Flow Biogas $_{Vessel}$ * Vol. Manure $_{Vessel}$ / Flow Manure $_{Vessel}$ + Flow Biogas $_{Vessel}$ * Time $_{Flaring}$)	As per venting data requirements.	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Methane Composition in Biogas / % CH_4	-	Estimated	Use previous year data, data that most accurately reflects current feedstock, or current year data retrospectively.	Annual	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Volume of Each Type of Fuel used to Supplement Flare / Vol Fuel $_i$	L / m^3 / other	Estimated	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P21 Venting	Steady State Flow Rate of Biogas from Vessel / Flow Biogas $_{Vessel}$	M^3 / hr	Estimated	Measure flow at current steady state operation.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Volume of Manure in Vessel at Steady State / Vol. Manure $_{Vessel}$	m^3	Estimated	Measure current volume of manure at steady state operation.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Steady State Flow Rate of Manure into Vessel / Flow Manure $_{Vessel}$	M^3 / hr	Estimated	Measure current flow rate of manure at steady state operation.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Time that vessel is venting / t	hr	Estimated	Reconciliation of records with power supply to the grid.	Annual	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

	Methane Composition in Biogas / % CH_4	-	Estimated	Use previous year data, data that most accurately reflects current feedstock, or current year data retrospectively.	Annual	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
Baseline SS's						
B8 Disposal at Landfill	Mass of Feedstock to Landfill / $Mass_{Feedstock\ Landfill}$	kg	N/A	N/A	N/A	N/A
B9 Incineration	Volume of Each Type of Fuel / Vol $Fuel_i$	L / m^3 / other	Estimated	Estimate for fuel required to incinerate given volume of feedstock.	Annual	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
B10 Electricity Production	Electricity Produced / Electricity	kWh	Estimated	Reconciliation of power delivered to the electricity grid.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
B11 Thermal Heat Produced	Volume of Each Type of Fuel / Vol $Fuel_i$	L / m^3 / other	Estimated	Calculated relative to metered quantity of Thermal Heat billed to the customer.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
B12b Fuel Extraction / Processing (Offsite)	Volume of Each Type of Fuel / Vol $Fuel_i$	L / m^3 / other	Estimated	Calculated relative to accounting records of biogas transferred to pipeline.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

APPENDIX A
Fugitive Emissions Good Practise Guidance

Fugitive Emissions Good Practise Guidance

It is crucial to the integrity of the project emission reduction claim that fugitive emissions of methane from the anaerobic decomposition of the biomass do not become a material source of emissions under the project condition. As such the following section provides a review of available guidance and provides recommendations for project proponents.

There are a number of standards that address fugitive emissions from similar systems including the Canadian Standards Association (CSA) Code for Digester Gas and Landfill Gas Installations (CAN/CGA-B105-M93) and the Safety Standards for Agricultural Biogas Installations from the German Federal Organization of Agricultural Cooperative Associations, Central Agency for Safety and Health Protection. These documents are both quite technical. As such, the following guidance has been developed to assist project developers in implementing maintenance and monitoring program that can ensure that fugitive emissions are immaterial.

General Recommendations

The following general recommendations are provided:

1. Trained, experience and certified personnel, as applicable, should be used to complete monitoring, testing, maintenance and construction/assembly work;
2. Seals that can be made permanent should made so;
3. Seals that are not permanent should remain accessible for testing and monitoring, as applicable; and,
4. Seals that are not accessible, should be tested thoroughly upon installation (i.e. underground piping connections).

Step-Wise Approach

<u>Step #1: Inventory Joints, Seals and Equipment</u>

An inventory of all joints, seals and equipment should be compiled. This list may be drawn from as-built drawings or from a thorough review of the facility. Labelling of joints may also be considered.

<u>Step #2: Categorize Joints, Seals and Equipment</u>

Each joint, seal and piece of equipment should be categorized as permanently tight and technically tight based on the following definitions:

> Permanently Tight
>
> Permanently technically tight facility and equipment parts are, e.g., welded equipment with removable components, whereby the necessary detachable connections have only to be operationally released very rarely, and the construction of which is designed in the same way as the following detachable pipe connections

(exception: metallically tightening connections). In addition, connecting pieces for the detachable attachment of pipes, armatures, or blind covers, whereby the necessary detachable connections have only to be operationally released very rarely, and the construction of which is designed in the same way as the following detachable pipe connections (exception: metallically tightening connections) can also be permanently technically tight.

Permanently technically tight pipe connections include non-detachable connections (i.e. welded) and detachable connections, which operationally are very rarely detached (i.e. professional flange connections).

Permanently technically tight connections for the connection of equipment, as far as they are rarely operationally detached, include pipe connections as mentioned above, and NPT-thread (National Pipe Paper Thread, cone type pipe thread) or other conical pipe threads, with sealing, as far as they are not exposed to changing thermal loads.

Beside pure design measures, technical measures combined with organizational measures can also lead to permanently technically tight equipment. This category includes, with appropriate monitoring and maintenance: dynamically loaded seals, e.g., for axle guides of pumps and thermally loaded seals of facility parts

Technically Tight

Equipment is technically tight if during a tightness test or tightness monitoring or control no leakage is detectable, e.g., by means of foam generating means or with leakage test or display instruments, whereby rare releases of gases and vapors cannot be excluded. This can include pumps whose technical tightness cannot be ensured permanently (e.g., with a simple sliding ring seal), and detachable connections which are rarely not detached.

Step #3: Establish Monitoring and Testing Procedures

Select appropriate testing and monitoring procedures for each of the joints, seals and equipment based on manufacturers specifications, industry practice or applicable standards documents. Relevance, cost effectiveness, access and category should all be included in the analysis. Permanently tight joints, seals and equipment may require less extensive and frequent monitoring as compared to technically tight joints, seals and equipment.

Monitoring and testing frequency should also be established. Recommendations are annual monitoring and testing for permanently tight joints, seals and equipment, and quarterly (at a minimum) for technically tight joints, seals and equipment. In addition, all joints should be checked each time they are maintained, replaced or otherwise disturbed.

A sample data form is provided in the following pages.

Step #4: Track Compliance with Monitoring and Testing Procedures

Compliance with monitoring and testing procedures should be tracked. Maintenance activity records should correlate with the testing and monitoring procedures.

A sample tracking form is provided in the following pages.

Table A1: Sample Monitoring and Testing Procedures Form

Item Number	Joint, Seal of Equipment			Category		Monitoring/Testing Procedures (including frequency)
	Name	Location	Description	Permanently Tight	Technically Tight	

Table A2: Sample Monitoring and Testing Tracking Form

Item Number	Date of Monitoring or Testing Event	Activity Completed	Results	Remedial Action Required	Notes

APPENDIX B:

Quantification Procedures for Flexibility Mechanisms

<table>
<tr><th colspan="7">Flexibility Mechanisms</th></tr>
<tr><td rowspan="6">P3 Feedstock Handling</td><td colspan="6">$Emissions_{Feedstock\ Handling} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})$; $\sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$</td></tr>
<tr><td>$Emissions_{Feedstock\ Handling}$</td><td>kg of CO2e</td><td>N/A</td><td>N/A</td><td>N/A</td><td>Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.</td></tr>
<tr><td>Volume of Each Type of Fuel / $Vol\ Fuel_i$</td><td>L / m^3 / other</td><td>Measured</td><td>Direct metering or reconciliation of volume in storage (including volumes received).</td><td>Continuous metering or monthly reconciliation.</td><td>Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.</td></tr>
<tr><td>CO_2 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ CO2}$</td><td>kg CO_2 per L / m^3 / other</td><td>Estimated</td><td>From Environment Canada reference documents.</td><td>Annual</td><td>Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.</td></tr>
<tr><td>CH_4 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ CH4}$</td><td>kg CH_4 per L / m^3 / other</td><td>Estimated</td><td>From Environment Canada reference documents.</td><td>Annual</td><td>Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.</td></tr>
<tr><td>$N_2 0$ Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ N2O}$</td><td>kg N_2O per L / m^3 / other</td><td>Estimated</td><td>From Environment Canada reference documents.</td><td>Annual</td><td>Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.</td></tr>
<tr><td rowspan="4">P4 Feedstock Transportation</td><td colspan="6">$Emissions_{Feedstock\ Transportation} = \sum (Emissions_{Truck} + Emissions_{Boat} + Emissions_{Train})$</td></tr>
<tr><td colspan="6">$Emissions_{Truck} = \sum (\#\ Loads_{Truck\ i} * Distance_{Truck\ i} * Fuel\ Eff_{Truck\ i} * EF\ Fuel_{CO2})$;
$\sum (\#\ Loads_{Truck\ i} * Distance_{Truck\ i} * Fuel\ Eff_{Truck\ i} * EF\ Fuel_{CH4})$; $\sum (\#\ Loads_{Truck\ i} * Distance_{Truck\ i} * Fuel\ Eff_{Truck\ i} * EF\ Fuel_{N2O})$</td></tr>
<tr><td>$Emissions_{Truck}$</td><td>kg of CO2e</td><td>N/A</td><td>N/A</td><td>N/A</td><td>Quantity being calculated.</td></tr>
<tr><td>Number of Loads for Each Truck on Each Route / $\#\ Loads_{Truck\ i}$</td><td>-</td><td>Measured</td><td>Number of loads recorded.</td><td>Every load recorded upon arrival at the energy from biomass facility.</td><td>Measuring the percent of total load weight would be an incremental industry practise.</td></tr>
</table>

	Distance Driven by Each Truck / $Distance_{Truck\ i}$	Km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Truck / $Fuel\ Eff_{Truck\ i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.
	CO_2 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	$Emissions_{Boat} = \sum(\#\ Loads_{Boat\ i} * Distance_{Boat\ i} * Fuel\ Eff_{Boat\ i} * EF\ Fuel_{CO2})$; $\sum(\#\ Loads_{Boat\ i} * Distance_{Boat\ i} * Fuel\ Eff_{Boat\ i} * EF\ Fuel_{CH4})$; $\sum(\#\ Loads_{Boat\ i} * Distance_{Boat\ i} * Fuel\ Eff_{Boat\ i} * EF\ Fuel_{N2O})$					
	$Emissions_{Boat}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Percent of the Total Load Weight on the Boat / % of Load	-	Measured	Percent of the total load weight on the boat measured as the mass of biomass as compared to the total mass of cargo.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Travelled by each Boat / $Distance_{Boat\ i}$	km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Boat / $Fuel\ Eff_{Boat\ i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.

	$Emissions_{Train} = \sum(\# Loads_{Train\ i} * Distance_{Train\ i} * Fuel\ Eff_{Train\ i} * EF\ Fuel_{CO2})$; $\sum(\# Loads_{Train\ i} * Distance_{Train\ i} * Fuel\ Eff_{Train\ i} * EF\ Fuel_{CH4})$; $\sum(\# Loads_{Train\ i} * Distance_{Train\ i} * Fuel\ Eff_{Train\ i} * EF\ Fuel_{N2O})$					
	$Emissions_{Train}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Percent of the Total Load Weight on the Train / % of Load	-	Measured	Percent of the total load weight on the train measured as the mass of biomass as compared to the total mass of cargo.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Travelled by Each Train / $Distance_{Train\ i}$	km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Train / $Fuel\ Eff_{Train\ i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.
P5 Feedstock Storage	$Emissions_{Feedstock\ Storage} = (Mass_{Feedstock} * k * Lo * \exp(-k * t)) * \rho_{CH4}$					
	$Emissions_{Feedstock\ Storage}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Mass of Feedstock / $Mass_{Feedstock}$	Mg	Estimated	Estimated from direct measurements of mass of feedstock material stored at the site.	Monthly	Estimation of the maximum mass of feedstock stored at the site at any given time.
	Methane Generation Rate Constant / k	1 / yr	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	Methane Generation Potential / Lo	m^3 / Mg	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	Time / t	yr	Measured	Number of days in the year.	Annual	Number of days in a year is an absolute value.
	Density of CH_4 at STP / ρ_{CH4}	kg / m^3	Estimated	Constant.	Annual	Property of methane

P10 Waste Transportation	$Emissions_{Waste\ Transportation} = \sum (Emissions_{Truck} + Emissions_{Boat} + Emissions_{Train})$					
	$Emissions_{Truck} = \sum (\#\ Loads_{Truck\ i} * Distance_{Truck\ i} * Fuel\ Eff_{Truck\ i} * EF\ Fuel_{CO2})$; $\sum (\#\ Loads_{Truck\ i} * Distance_{Truck\ i} * Fuel\ Eff_{Truck\ i} * EF\ Fuel_{CH4})$; $\sum (\#\ Loads_{Truck\ i} * Distance_{Truck\ i} * Fuel\ Eff_{Truck\ i} * EF\ Fuel_{N2O})$					
	$Emissions_{Truck}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Number of Loads for Each Truck on Each Route / $\#\ Loads_{Truck\ i}$	-	Measured	Number of loads recorded.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Driven by Each Truck / $Distance_{Truck\ i}$	km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Truck / $Fuel\ Eff_{Truck\ i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.
	CO_2 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / $EF\ Fuel_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	$Emissions_{Boat} = \sum (\#\ Loads_{Boat\ i} * Distance_{Boat\ i} * Fuel\ Eff_{Boat\ i} * EF\ Fuel_{CO2})$; $\sum (\#\ Loads_{Boat\ i} * Distance_{Boat\ i} * Fuel\ Eff_{Boat\ i} * EF\ Fuel_{CH4})$; $\sum (\#\ Loads_{Boat\ i} * Distance_{Boat\ i} * Fuel\ Eff_{Boat\ i} * EF\ Fuel_{N2O})$					
	$Emissions_{Boat}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.

	Percent of the Total Load Weight on the Boat / % of Load	-	Measured	Percent of the total load weight on the boat measured as the mass of biomass as compared to the total mass of cargo.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Travelled by each Boat / Distance $_{Boat\ i}$	km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Boat / Fuel Eff $_{Boat\ i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.
	Emissions $_{Train}$ = $\sum$ (# Loads $_{Train\ i}$ * Distance $_{Train\ i}$ * Fuel Eff $_{Train\ i}$ * EF Fuel $_{CO2}$) ; $\sum$ (# Loads $_{Train\ i}$ * Distance $_{Train\ i}$ * Fuel Eff $_{Train\ i}$ * EF Fuel $_{CH4}$) ; $\sum$ (# Loads $_{Train\ i}$ * Distance $_{Train\ i}$ * Fuel Eff $_{Train\ i}$ * EF Fuel $_{N2O}$)					
	Emissions $_{Train}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Percent of the Total Load Weight on the Train / % of Load	-	Measured	Percent of the total load weight on the train measured as the mass of biomass as compared to the total mass of cargo.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Travelled by Each Train / Distance $_{Train\ i}$	km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Train / Fuel Eff $_{Train\ i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.
P11 Waste Disposal	Emissions $_{Waste\ Disposal}$ = (Mass $_{Waste}$ * MCF * DOC * DOC$_F$ * F * 16/12 - R) * (1 - OX)					
	Emissions $_{Waste\ Disposal}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.

	Mass of Waste / Mass $_{Waste}$	kg	Measured	Direct measurement of mass of waste diverted to disposal site or landfill facility.	Measurement of each load of waste prior to its being disposed of onsite or as it is received at the landfill facility.	Measuring the mass of each load prior to its being disposed of onsite or as it is received at the landfill facility represents the industry practise.
	Methane Correction Factor / MCF	-	Estimated	Calculated based on IPCC and Environment Canada guidelines, provided in Appendix C and D.	Annual	Values calculated based on values published by IPCC. Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Degradable Organic Carbon / DOC	-	Estimated	Calculated based on IPCC and Environment Canada guidelines, provided in Appendix C and D.	Annual	Values calculated based on values published by IPCC. Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Fraction of Degradable Organic Carbon Dissimilated / DOC_F	-	Estimated	Calculated based on IPCC and Environment Canada guidelines, provided in Appendix C and D.	Annual	Values calculated based on values published by IPCC. Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Fraction of CH_4 in Off gas from Disposal Site / F	-	Estimated	From IPCC guidelines.	Annual	Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Recovered CH_4 at Disposal Site / R	kg of CH4	Measured	From IPCC guidelines.	Annual	Reference values adjusted periodically as part of internal IPCC review of its methodologies.
	Oxidation Factor / OX	-	Estimated	From IPCC guidelines.	Annual	Reference values adjusted periodically as part of internal IPCC review of its methodologies.

P13 Fertilizer Transportation	$Emissions_{Fertilizer\ Transportation} = \sum (Emissions_{Truck} + Emissions_{Boat} + Emissions_{Train})$					
	$Emissions_{Truck} = \sum (\#\ Loads_{Truck\ i} * Distance_{Truck\ i} * Fuel\ Eff_{Truck\ i} * EF\ Fuel_{CO2})$; $\sum (\#\ Loads_{Truck\ i} * Distance_{Truck\ i} * Fuel\ Eff_{Truck\ i} * EF\ Fuel_{CH4})$; $\sum (\#\ Loads_{Truck\ i} * Distance_{Truck\ i} * Fuel\ Eff_{Truck\ i} * EF\ Fuel_{N2O})$					
	$Emissions_{Truck}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Number of Loads for Each Truck on Each Route / # $Loads_{Truck\ i}$	-	Measured	Number of loads recorded.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Driven by Each Truck / $Distance_{Truck\ i}$	km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Truck / Fuel $Eff_{Truck\ i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.
	CO_2 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	$Emissions_{Boat} = \sum (\#\ Loads_{Boat\ i} * Distance_{Boat\ i} * Fuel\ Eff_{Boat\ i} * EF\ Fuel_{CO2})$; $\sum (\#\ Loads_{Boat\ i} * Distance_{Boat\ i} * Fuel\ Eff_{Boat\ i} * EF\ Fuel_{CH4})$; $\sum (\#\ Loads_{Boat\ i} * Distance_{Boat\ i} * Fuel\ Eff_{Boat\ i} * EF\ Fuel_{N2O})$					
	$Emissions_{Boat}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.

	Percent of the Total Load Weight on the Boat / % of Load	-	Measured	Percent of the total load weight on the boat measured as the mass of biomass as compared to the total mass of cargo.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Travelled by each Boat / $\text{Distance}_{\text{Boat i}}$	km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Boat / $\text{Fuel Eff}_{\text{Boat i}}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.
	$\text{Emissions}_{\text{Train}} = \sum (\text{\# Loads}_{\text{Train i}} * \text{Distance}_{\text{Train i}} * \text{Fuel Eff}_{\text{Train i}} * \text{EF Fuel}_{CO2})$; $\sum (\text{\# Loads}_{\text{Train i}} * \text{Distance}_{\text{Train i}} * \text{Fuel Eff}_{\text{Train i}} * \text{EF Fuel}_{CH4})$; $\sum (\text{\# Loads}_{\text{Train i}} * \text{Distance}_{\text{Train i}} * \text{Fuel Eff}_{\text{Train i}} * \text{EF Fuel}_{N2O})$					
	$\text{Emissions}_{\text{Train}}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Percent of the Total Load Weight on the Train / % of Load	-	Measured	Percent of the total load weight on the train measured as the mass of biomass as compared to the total mass of cargo.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Travelled by Each Train / $\text{Distance}_{\text{Train i}}$	km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Train / $\text{Fuel Eff}_{\text{Train i}}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.
B3 Feedstock Handling	$\text{Emissions}_{\text{Feedstock Handling}} = \sum (\text{Vol. Fuel}_i * \text{EF Fuel}_{i\,CO2})$; $\sum (\text{Vol. Fuel}_i * \text{EF Fuel}_{i\,CH4})$; $\sum (\text{Vol. Fuel}_i * \text{EF Fuel}_{i\,N2O})$					
	$\text{Emissions}_{\text{Feedstock Handling}}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregated for each of these SS's.

	Volume of Each Type of Fuel / Vol Fuel $_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
B4 Feedstock Transportation	$\text{Emissions}_{\text{Feedstock Transportation}} = \sum(\text{Emissions}_{\text{Truck}} + \text{Emissions}_{\text{Boat}} + \text{Emissions}_{\text{Train}})$					
	$\text{Emissions}_{\text{Truck}} = \sum(\#\ \text{Loads}_{\text{Truck i}} * \text{Distance}_{\text{Truck i}} * \text{Fuel Eff}_{\text{Truck i}} * \text{EF Fuel}_{\text{CO2}})$; $\sum(\#\ \text{Loads}_{\text{Truck i}} * \text{Distance}_{\text{Truck i}} * \text{Fuel Eff}_{\text{Truck i}} * \text{EF Fuel}_{\text{CH4}})$; $\sum(\#\ \text{Loads}_{\text{Truck i}} * \text{Distance}_{\text{Truck i}} * \text{Fuel Eff}_{\text{Truck i}} * \text{EF Fuel}_{\text{N2O}})$					
	Emissions $_{\text{Truck}}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Number of Loads for Each Truck on Each Route / # Loads $_{\text{Truck i}}$	-	Measured	Number of loads recorded.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Driven by Each Truck / Distance $_{\text{Truck i}}$	Km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Truck / Fuel Eff $_{\text{Truck i}}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.

	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	$\text{Emissions}_{Boat} = \sum(\#\ \text{Loads}_{Boat\ i} * \text{Distance}_{Boat\ i} * \text{Fuel Eff}_{Boat\ i} * \text{EF Fuel}_{CO2})$; $\sum(\#\ \text{Loads}_{Boat\ i} * \text{Distance}_{Boat\ i} * \text{Fuel Eff}_{Boat\ i} * \text{EF Fuel}_{CH4})$; $\sum(\#\ \text{Loads}_{Boat\ i} * \text{Distance}_{Boat\ i} * \text{Fuel Eff}_{Boat\ i} * \text{EF Fuel}_{N2O})$					
	Emissions $_{Boat}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Percent of the Total Load Weight on the Boat / % of Load	-	Measured	Percent of the total load weight on the boat measured as the mass of biomass as compared to the total mass of cargo.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Travelled by each Boat / Distance $_{Boat\ i}$	Km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Boat / Fuel Eff $_{Boat\ i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.
	$\text{Emissions}_{Train} = \sum(\#\ \text{Loads}_{Train\ i} * \text{Distance}_{Train\ i} * \text{Fuel Eff}_{Train\ i} * \text{EF Fuel}_{CO2})$; $\sum(\#\ \text{Loads}_{Train\ i} * \text{Distance}_{Train\ i} * \text{Fuel Eff}_{Train\ i} * \text{EF Fuel}_{CH4})$; $\sum(\#\ \text{Loads}_{Train\ i} * \text{Distance}_{Train\ i} * \text{Fuel Eff}_{Train\ i} * \text{EF Fuel}_{N2O})$					
	Emissions $_{Train}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.

	Percent of the Total Load Weight on the Train / % of Load	-	Measured	Percent of the total load weight on the train measured as the mass of biomass as compared to the total mass of cargo.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Travelled by Each Train / Distance $_{Train\ i}$	Km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Train / Fuel Eff $_{Train\ i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.
B6 Fertilizer Transportation	Emissions $_{Fertilizer\ Transportation}$ = $\sum$ (Emissions $_{Truck}$ + Emissions $_{Boat}$ + Emissions $_{Train}$)					
	Emissions $_{Truck}$ = $\sum$ (# Loads $_{Truck\ i}$ * Distance $_{Truck\ i}$ * Fuel Eff $_{Truck\ i}$ * EF Fuel $_{CO2}$) ; $\sum$ (# Loads $_{Truck\ i}$ * Distance $_{Truck\ i}$ * Fuel Eff $_{Truck\ i}$ * EF Fuel $_{CH4}$) ; $\sum$ (# Loads $_{Truck\ i}$ * Distance $_{Truck\ i}$ * Fuel Eff $_{Truck\ i}$ * EF Fuel $_{N2O}$)					
	Emissions $_{Truck}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Number of Loads for Each Truck on Each Route / # Loads $_{Truck\ i}$	-	Measured	Number of loads recorded.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Driven by Each Truck / Distance $_{Truck\ i}$	Km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Truck / Fuel Eff $_{Truck\ i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

	N_2O Emissions Factor for Each Type of Fuel / EF Fuel $_{i\,N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	Emissions $_{Boat}$ = $\sum$(# Loads $_{Boat\,i}$ * Distance $_{Boat\,i}$ * Fuel Eff $_{Boat\,i}$ * EF Fuel $_{CO2}$) ; $\sum$(# Loads $_{Boat\,i}$ * Distance $_{Boat\,i}$ * Fuel Eff $_{Boat\,i}$ * EF Fuel $_{CH4}$) ; $\sum$(# Loads $_{Boat\,i}$ * Distance $_{Boat\,i}$ * Fuel Eff $_{Boat\,i}$ * EF Fuel $_{N2O}$)					
	Emissions $_{Boat}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Percent of the Total Load Weight on the Boat / % of Load	-	Measured	Percent of the total load weight on the boat measured as the mass of biomass as compared to the total mass of cargo.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Travelled by each Boat / Distance $_{Boat\,i}$	km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Boat / Fuel Eff $_{Boat\,i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.
	Emissions $_{Train}$ = $\sum$(# Loads $_{Train\,i}$ * Distance $_{Train\,i}$ * Fuel Eff $_{Train\,i}$ * EF Fuel $_{CO2}$) ; $\sum$(# Loads $_{Train\,i}$ * Distance $_{Train\,i}$ * Fuel Eff $_{Train\,i}$ * EF Fuel $_{CH4}$) ; $\sum$(# Loads $_{Train\,i}$ * Distance $_{Train\,i}$ * Fuel Eff $_{Train\,i}$ * EF Fuel $_{N2O}$)					
	Emissions $_{Train}$	kg of CO2e	N/A	N/A	N/A	Quantity being calculated.
	Percent of the Total Load Weight on the Train / % of Load	-	Measured	Percent of the total load weight on the train measured as the mass of biomass as compared to the total mass of cargo.	Every load recorded upon arrival at the energy from biomass facility.	Measuring the percent of total load weight would be an incremental industry practise.
	Distance Travelled by Each Train / Distance $_{Train\,i}$	km	Measured	Distance each load travels.	Annual	The distance of each route is measured once a year.
	Fuel Efficiency of Each Type of Train / Fuel Eff $_{Train\,i}$	L per 100 km	Estimated	Volume of fuel use is divided by distance travelled.	Monthly	This method is conservative as it incorporates all travel time and idling.

APPENDIX C:

Contingent Data Collection Procedures for Flexibility Mechanisms

Flexibility Mechanisms						
P3 Feedstock Handling	Volume of Each Type of Fuel / Vol Fuel $_i$	L / m^3 / other	Estimated	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Electricity Usage / Electricity	kWh	Estimated	Reconciliation of power requirements for facility as per equipment output ratings.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P4 Feedstock Transportation	Number of Loads for Each Truck on Each Route / # Loads $_{Truck\ i}$	-	Measured	Mass of material received divided by average load per truck for a sample of 10 loads over a seven day period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Driven by Each Truck / Distance $_{Truck\ i}$	km	Measured	Total number of kilometres driven by truck over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Truck / Fuel Eff $_{Truck\ i}$	L per km	Estimated	Average fuel efficiency for a truck in that class as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Percent of the Total Load Weight on the Boat / % of Load	-	Measured	Total number of kilometres driven by truck over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Travelled by Boat / Distance $_{Boat\ i}$	km	Measured	Total number of kilometres covered by the boat on that route over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Boat / Fuel Eff $_{Boat\ i}$	L per km	Estimated	Average fuel efficiency for a boat of that type as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

	Percent of the Total Load Weight on the Train / % of Load	-	Measured	Percent of the total load weight on the train measured as the mass of biomass as compared to the total mass of cargo.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Travelled by Each Train / $Distance_{Train\ i}$	km	Measured	Total number of kilometres covered by the boat on that route over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Train / $Fuel\ Eff_{Train\ i}$	L per km	Estimated	Average fuel efficiency for a boat of that type as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P5 Feedstock Storage	N/A	N/A	N/A	N/A	N/A	N/A
P10 Waste Transportation	Number of Loads for Each Truck on Each Route / $\#\ Loads_{Truck\ i}$	-	Measured	Mass of material received divided by average load per truck for a sample of 10 loads over a seven day period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Driven by Each Truck / $Distance_{Truck\ i}$	km	Measured	Total number of kilometres driven by truck over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Truck / $Fuel\ Eff_{Truck\ i}$	L per km	Estimated	Average fuel efficiency for a truck in that class as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Percent of the Total Load Weight on the Boat / % of Load	-	Measured	Total number of kilometres driven by truck over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Travelled by Boat / $Distance_{Boat\ i}$	km	Measured	Total number of kilometres covered by the boat on that route over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

	Fuel Efficiency of Each Type of Boat / Fuel Eff $_{Boat\ i}$	L per km	Estimated	Average fuel efficiency for a boat of that type as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Percent of the Total Load Weight on the Train / % of Load	-	Measured	Percent of the total load weight on the train measured as the mass of biomass as compared to the total mass of cargo.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Travelled by Each Train / Distance $_{Train\ i}$	km	Measured	Total number of kilometres covered by the boat on that route over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Train / Fuel Eff $_{Train\ i}$	L per km	Estimated	Average fuel efficiency for a boat of that type as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
P11 Waste Disposal	N/A	N/A	N/A	N/A	N/A	N/A
P13 Fertilizer Transportation	Number of Loads for Each Truck on Each Route / # Loads $_{Truck\ i}$	-	Measured	Mass of material received divided by average load per truck for a sample of 10 loads over a seven day period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Driven by Each Truck / Distance $_{Truck\ i}$	km	Measured	Total number of kilometres driven by truck over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Truck / Fuel Eff $_{Truck\ i}$	L per km	Estimated	Average fuel efficiency for a truck in that class as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Percent of the Total Load Weight on the Boat / % of Load	-	Measured	Total number of kilometres driven by truck over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

	Distance Travelled by Boat / Distance $_{Boat\ i}$	km	Measured	Total number of kilometres covered by the boat on that route over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Boat / Fuel Eff $_{Boat\ i}$	L per km	Estimated	Average fuel efficiency for a boat of that type as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Percent of the Total Load Weight on the Train / % of Load	-	Measured	Percent of the total load weight on the train measured as the mass of biomass as compared to the total mass of cargo.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Travelled by Each Train / Distance $_{Train\ i}$	km	Measured	Total number of kilometres covered by the boat on that route over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Train / Fuel Eff $_{Train\ i}$	L per km	Estimated	Average fuel efficiency for a boat of that type as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
B3 Manure Handling	Volume of Each Type of Fuel / Vol Fuel $_i$	L / m^3 / other	Estimated	Reconciliation of volume of fuel purchased within given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Electricity Usage / Electricity	kWh	Estimated	Reconciliation of power requirements for facility as per equipment output ratings.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
B4 Manure Transportation	Number of Loads for Each Truck on Each Route / # Loads $_{Truck\ i}$	-	Measured	Mass of material received divided by average load per truck for a sample of 10 loads over a seven day period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

	Distance Driven by Each Truck / Distance $_{Truck\ i}$	km	Measured	Total number of kilometres driven by truck over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Truck / Fuel Eff $_{Truck\ i}$	L per km	Estimated	Average fuel efficiency for a truck in that class as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Percent of the Total Load Weight on the Boat / % of Load	-	Measured	Total number of kilometres driven by truck over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Travelled by Boat / Distance $_{Boat\ i}$	km	Measured	Total number of kilometres covered by the boat on that route over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Boat / Fuel Eff $_{Boat\ i}$	L per km	Estimated	Average fuel efficiency for a boat of that type as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Percent of the Total Load Weight on the Train / % of Load	-	Measured	Percent of the total load weight on the train measured as the mass of biomass as compared to the total mass of cargo.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Travelled by Each Train / Distance $_{Train\ i}$	km	Measured	Total number of kilometres covered by the boat on that route over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Train / Fuel Eff $_{Train\ i}$	L per km	Estimated	Average fuel efficiency for a boat of that type as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

B6 Fertilizer Transportation	Number of Loads for Each Truck on Each Route / # Loads $_{\text{Truck i}}$	-	Measured	Mass of material received divided by average load per truck for a sample of 10 loads over a seven day period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Driven by Each Truck / Distance $_{\text{Truck i}}$	km	Measured	Total number of kilometres driven by truck over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Truck / Fuel Eff $_{\text{Truck i}}$	L per km	Estimated	Average fuel efficiency for a truck in that class as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Percent of the Total Load Weight on the Boat / % of Load	-	Measured	Total number of kilometres driven by truck over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Travelled by Boat / Distance $_{\text{Boat i}}$	km	Measured	Total number of kilometres covered by the boat on that route over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Fuel Efficiency of Each Type of Boat / Fuel Eff $_{\text{Boat i}}$	L per km	Estimated	Average fuel efficiency for a boat of that type as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Percent of the Total Load Weight on the Train / % of Load	-	Measured	Percent of the total load weight on the train measured as the mass of biomass as compared to the total mass of cargo.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Distance Travelled by Each Train / Distance $_{\text{Train i}}$	km	Measured	Total number of kilometres covered by the boat on that route over the period divided by two times the number of loads.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

	Fuel Efficiency of Each Type of Train / $\text{Fuel Eff}_{\text{Train i}}$	L per km	Estimated	Average fuel efficiency for a boat of that type as published by industry association.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

APPENDIX D:

Calculation of DOC

Calculation of DOC

The following calculations were conducted according to the information outlined in the "National Inventory Report – Greenhouse Gas Sources and Sinks in Canada, 1990-2004", Environment Canada, April 2006.

Estimates of the degradable organic carbon (DOC) present in a waste stream can be calculated using the following equation:

$$\mathbf{L_0 = MCF * DOC * DOC_F * F * 16/12 * 1000\ kg\ CH_4/t\ CH_4}$$

Where:

L_O	$= CH_4$ generation potential (kg CH_4/ t waste)
MCF	$= CH_4$ correction factor (fraction)
DOC	= degradable organic carbon (t C/t waste)
DOC_F	= fraction DOC dissimilated
F	= fraction CH_4 in landfill gas
16/12	= stoichiometric factor

According to the IPCC Guidelines, the MCF for managed landfill sites has a value of 1.0. The fraction of CH_4 (F) emitted from a landfill ranges from 0.4 to 0.6 and was assumed to be 0.5. The IPCC default DOC_F value of 0.77 was used. The DOC values in the following table were calculated using average Lo values for each province published by Environment Canada (2006).

TABLE A3.1: Estimates of DOC by Province

Province	Lo (value after 1990)	DOC (calculated)
British Columbia	108.8	0.21
Alberta	100.0	0.19
Saskatchewan	106.8	0.21
Manitoba	92.4	0.18
Ontario	90.3	0.18
Quebec	127.8	0.25
New Brunswick	117.0	0.23
Prince Edward Island	117.0	0.23
Nova Scotia	89.8	0.17
Newfoundland and Labrador	102.2	0.20
Northwest Territories and Nunavut	117.0	0.23
Yukon	117.0	0.23

APPENDIX E:

Parameters for Use in Calculations Based on Diversion from Landfills by Landfill Type

TABLE A4.1: Landfill Type-Based Factors

	Mixed-Waste Landfills				Wood Waste Landfills
Parameter	**Managed**	**Unmanaged – Deep (>= 5m waste)**	**Unmanaged – Shallow (< 5m waste)**	**Uncategorized**	
Methane Correction Factor (MCF)	1.0	0.8	0.4	0.6	0.8[a]
Fraction of CH_4 in landfill gas (F)	0.5				
Fraction of degradable organic carbon dissimilated (DOC_F)	0.77				0.5
Fraction of degradable organic carbon (DOC)	See Appendix A				0.3

a - the default condition for a wood waste landfill is an unmanaged, deep landfill (Environment Canada, 2006). This parameter may be changed if the emissions are being calculated for an alternate type of wood waste landfill.